
User's Manual



TC 48 / TC 96
Auto-Tune Fuzzy / PID
Process / Temperature Controller



Warning Symbol

The Symbol calls attention to an operating procedure, practice, or the like, which, if not correctly performed or adhered to, could result in personal injury or damage to or destruction of part or all of the product and system. Do not proceed beyond a warning symbol until the indicated conditions are fully understood and met.

Use the Manual

- | | |
|-------------------|-------------------|
| • Installers | Read Chapter 1, 2 |
| • System Designer | Read All Chapters |
| • Expert User | Read Page 12 |

NOTE:

It is strongly recommended that a process should incorporate a LIMIT CONTROL like L91 which will shut down the equipment at a preset process condition in order to preclude possible damage to products or system.

Some programming parameters shown in this manual may not be available on currently offered models.

Information in this user's manual is subject to change without

This manual is applicable for the products with software version 23 and later version.

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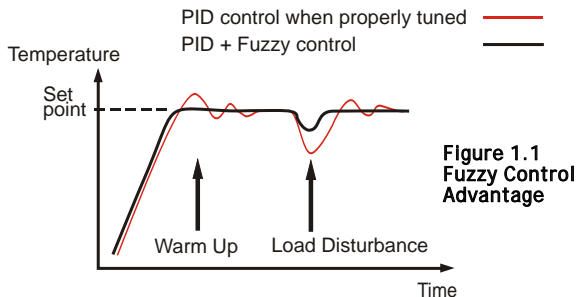
Chapter 1 Overview

1-1 General

The Fuzzy Logic plus PID microprocessor-based controller series, incorporate two bright, easy to read 4-digit LED displays, indicating process value and set point value. The Fuzzy Logic technology enables a process to reach a predetermined set point in the shortest time, with the minimum of overshoot during power-up or external load disturbance.

The TC48 is a 1/16 DIN size panel mount controller. The TC96 is a 1/8 DIN size panel mount controller. These units are powered by 11-26 or 90-250 VDC /VAC supply, incorporating a 2 amp control relay output as standard. The units are fully programmable for PT100 and thermocouple types J,K, T, E, B, R, S, N, L with no need to modify the unit. The input signal is digitized by using a 18-bit A to D converter. Its fast sampling rate allows the unit to control fast processes.

By using proprietary Fuzzy modified PID technology, the control loop will minimize the overshoot and undershoot in a shortest time. The following diagram is a comparison of results with and without Fuzzy technology.



**Figure 1.1
Fuzzy Control
Advantage**

High Accuracy

The series are manufactured with custom designed ASIC(Application Specific Integrated Circuit) technology which contains a 18-bit A to D converter for high resolution measurement (true 0.1 °F resolution for thermocouple and PT100) and a 15-bit D to A converter for linear current or voltage control output. The ASIC technology provides improved operating performance, low cost, enhanced reliability and higher density.

Fast Sampling Rate

The sampling rate of the input A to D converter reaches 5 times/second. The fast sampling rate allows this series to control fast processes.

Fuzzy Control

The function of Fuzzy control is to adjust PID parameters from time to time in order to make manipulation output value more flexible and adaptive to various processes. The results is to enable a process to reach a predetermined set point in the shortest time, with the minimum of overshoot and undershoot during power-up or external load disturbance.

Auto-tune

The auto-tune function allows the user to simplify initial setup for a new system. A clever algorithm is provided to obtain an optimal set of control parameters for the process, and it can be applied either as the process is warming up (cold start) or as the process has been in steady state (warm start).

Lockout Protection

According to actual security requirement, one of four lockout levels can be selected to prevent the unit from being changed by unauthorized personnel.

Bumpless Transfer

Bumpless transfer allows the controller to continue to control by using its previous value as the sensor breaks. Hence, the process can be controlled temporarily in open loop mode.

Soft-start Ramp

The ramping function is performed during power up as well as any time the set point is changed. It can ramp up or ramp down. The process value will reach the set point with a predetermined constant rate.

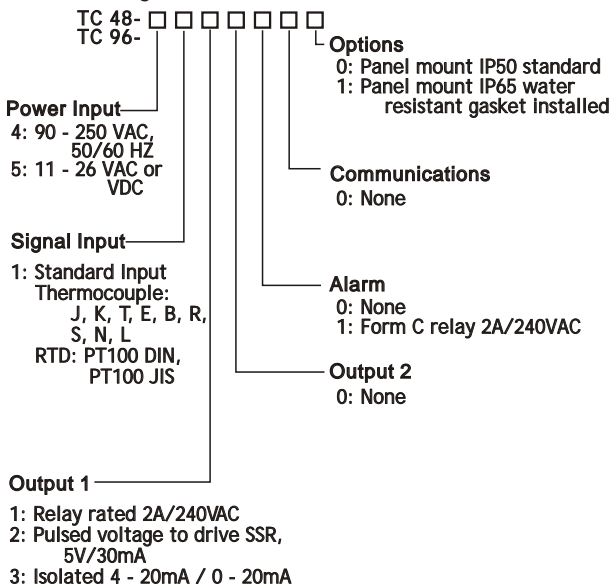
Digital Filter

A first order low pass filter with a programmable time constant is used to improve the stability of process value. This is particularly useful in certain applications where the process value is too unstable to be read.

SEL Function

The units have the flexibility for user to select those parameters which are most significant to him and put these parameters in the front of display sequence. Up to 8 parameters can be selected to allow the user to build his own display sequence.

1-2 Ordering Code



NOTE: Not all options are currently available with all models.

1- 3 Keys and Displays

KEYPAD OPERATION

SCROLL KEY :

This key is used to select a parameter to be viewed or adjusted.

UP KEY :

This key is used to increase the value of selected parameter.

DOWN KEY :

This key is used to decrease the value of selected parameter.




RESET KEY :

This key is used to:


1. Revert the display to the process value.
2. Reset the latching alarm, once the alarm condition is removed.
3. Stop the manual control mode, auto-tuning mode, and calibration mode.
4. Clear communication error and auto-tuning error messages.
5. Restart the dwell timer when the dwell timer has been timed out.
6. Enter the manual control menu during failure mode occurrences.


ENTER KEY : Press for 5 seconds or longer .

Press  for 5 seconds to:

1. Enter setup menu. The display shows  .
2. Enter manual control mode when manual control mode  is selected.
3. Enter auto-tuning mode when auto-tuning mode  is selected.
4. Perform calibration to a selected parameter during the calibration procedure.

Press  for 6.2 seconds to select manual control mode.

Press  for 7.4 seconds to select auto-tuning mode.

Press  for 8.6 seconds to select calibration mode.

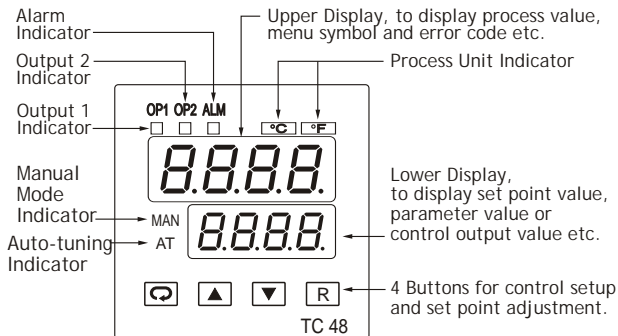
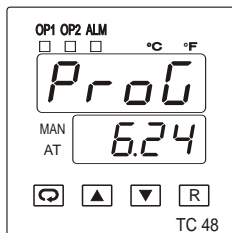


Figure 1.2 Front Panel Description

Table 1.1 Display Form of Characters

A	<i>A</i>	E	<i>E</i>	I	<i>I</i>	N	<i>N</i>	S	<i>S</i>	X	
B	<i>b</i>	F	<i>F</i>	J	<i>J</i>	O	<i>O</i>	T	<i>t</i>	Y	<i>y</i>
C	<i>C</i>	G	<i>G</i>	K	<i>K</i>	P	<i>P</i>	U	<i>u</i>	Z	
c	<i>c</i>	H	<i>H</i>	L	<i>L</i>	Q		V	<i>v</i>	?	<i>?</i>
D	<i>d</i>	h	<i>h</i>	M	<i>M</i>	R	<i>r</i>	W		=	<i>=</i>

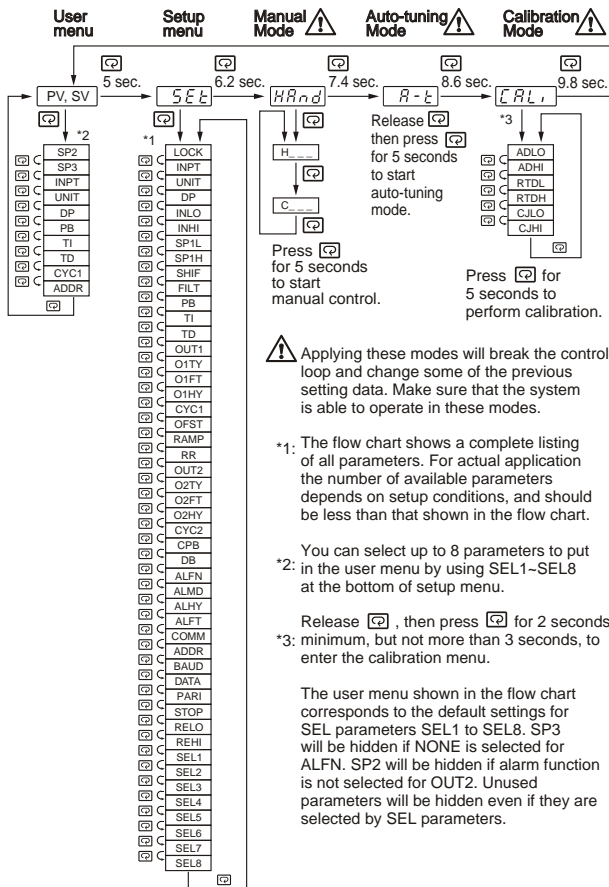


Display program code of the product for 2.5 seconds.

The lower display shows program no. 6 for TC 48 with version 24.
The program no. for TC 96 is 11.

Figure 1.3 Display of Initial Stage

1- 4 Menu Overview



⚠ Applying these modes will break the control loop and change some of the previous setting data. Make sure that the system is able to operate in these modes.

*1: The flow chart shows a complete listing of all parameters. For actual application the number of available parameters depends on setup conditions, and should be less than that shown in the flow chart.

You can select up to 8 parameters to put
*2: in the user menu by using SEL1~SEL8 at the bottom of setup menu.

Release [] , then press [] for 2 seconds
*3: minimum, but not more than 3 seconds, to enter the calibration menu.

The user menu shown in the flow chart corresponds to the default settings for SEL parameters SEL1 to SEL8. SP3 will be hidden if NONE is selected for ALFN. SP2 will be hidden if alarm function is not selected for OUT2. Unused parameters will be hidden even if they are selected by SEL parameters.

1-5 Parameter Descriptions

Parameter Notation	Parameter Description	Range	Default Value
SP1	Set point for output 1	Low: SP1L High :SP1H	25.0 C (77.0 F)
SP2	Set point for output 2 when output 2 performs alarm function	Low: -19999 High :45536	10.0 C (18.0 F)
SP3	Set point for alarm or dwell timer output	Low: -19999 High: 45536	10.0 C (18.0 F)
LOCK	Select parameters to be locked	0 none : No parameter is locked 1 SEt : Setup data are locked 2 USEr : Setup data and User data except Set point are locked 3 ALL : All data are locked	0
INPT	Input sensor selection	0 J-TC : J type thermocouple 1 K-TC : K type thermocouple 2 T-TC : T type thermocouple 3 E-TC : E type thermocouple 4 B-TC : B type thermocouple 5 R-TC : R type thermocouple 6 S-TC : S type thermocouple 7 N-TC : N type thermocouple 8 L-TC : L type thermocouple 9 Pt.Dn : PT 100 ohms DIN curve 10 Pt.JS : PT 100 ohms JIS curve 11 4-20 : 4 - 20 mA linear current input 12 0-20 : 0 - 20 mA linear current input 13 0-60 : 0 - 60 mV linear millivolt input 14 0-1V : 0 - 1V linear voltage input 15 0-5V : 0 - 5V linear voltage input 16 1-5V : 1 - 5V linear voltage input 17 0-10V : 0 - 10V linear voltage input	1 (0)

Parameter Notation	Parameter Description	Range	Default Value
UNIT	Input unit selection	0 °C : Degree C unit 1 °F : Degree F unit 2 P_U : Process unit	0 (1)
DP	Decimal point selection	0 no.dP : No decimal point 1 1-dP : 1 decimal digit 2 2-dP : 2 decimal digits 3 3-dP : 3 decimal digits	1
INLO	Input low scale value	Low: -19999 High: 45486	-17.8 C (0 F)
INHI	Input high scale value	Low: INLO+50 High: 45536	93.3 C (200.0 F)
SP1L	Low limit of set point value	Low: -19999 High: 45536	-17.8 C (0 F)
SP1H	High limit of set point value	Low: SP1L High: 45536	537.8 C (1000 F)
SHIF	PV shift (offset) value	Low: -200.0 C (-360.0 F) High: 200.0 C (360.0 F)	0.0
FILT	Filter damping time constant of PV	0 0 : 0 second time constant 1 0.2 : 0.2 second time constant 2 0.5 : 0.5 second time constant 3 1 : 1 second time constant 4 2 : 2 seconds time constant 5 5 : 5 seconds time constant 6 10 : 10 seconds time constant 7 20 : 20 seconds time constant 8 30 : 30 seconds time constant 9 60 : 60 seconds time constant	2

Parameter Notation	Parameter Description	Range	Default Value
PB	Proportional band value	Low: 0 High: 500.0 LC (900.0 LF)	10.0 C (18.0 F)
TI	Integral time value	Low: 0 High: 1000 sec	100
TD	Derivative time value	Low: 0 High: 360.0 sec	25.0
OUT1	Output 1 function	0 <i>REY</i> : Reverse (heating) control action 1 <i>dir</i> : Direct (cooling) control action	0
O1TY	Output 1 signal type	0 <i>RELY</i> : Relay output 1 <i>SS-d</i> : Solid state relay drive output 2 <i>SSr</i> : Solid state relay output 3 <i>4-20</i> : 4-20 mA current module 4 <i>0-20</i> : 0 - 20 mA current module 5 <i>0-1V</i> : 0 - 1V voltage module 6 <i>0-5V</i> : 0 - 5V voltage module 7 <i>1-5V</i> : 1 - 5V voltage module 8 <i>0-10</i> : 0 - 10V voltage module	0
O1FT	Output 1 failure transfer mode	Select BPLS (bumpless transfer) or 0.0 ~ 100.0 % to continue output 1 control function if the sensor fails, or select OFF (0) or ON (1) for ON-OFF control.	0
O1HY	Output 1 ON-OFF control hysteresis	Low: 0.1 High: 50.0 C(90.0 F)	0.1 C (0.2 F)
CYC1	Output 1 cycle time	Low: 0.1 High: 90.0 sec.	18.0
OFST	Offset value for P control	Low: 0 High: 100.0 %	25.0
RAMP	Ramp function selection	0 <i>nonE</i> : No Ramp Function 1 <i>min</i> : Use unit/minute as Ramp Rate 2 <i>hr</i> : Use unit/hour as Ramp Rate	0


Parameter Notation	Parameter Description	Range	Default Value
RR	Ramp rate	Low: 0 High: 500.0 C (900.0 F)	0.0
OUT2	Output 2 function	0 none : Output 2 No Function 2 DEH : Deviation High Alarm 3 DEL : Deviation Low Alarm 6 PUH : Process High Alarm 7 PUL : Process Low Alarm 8 COOL : Cooling PID Function	2
O2TY	Output 2 signal type	0 RELY : Relay output 1 SSrd : Solid state relay drive output 2 SSr : Solid state relay output 3 4-20 : 4 - 20 mA current module 4 0-20 : 0 - 20 mA current module 5 0-1V : 0 - 1V voltage module 6 0-5V : 0 - 5V voltage module 7 1-5V : 1 - 5V voltage module 8 0-10 : 0 - 10V voltage module	0
O2FT	Output 2 failure transfer mode	Select BPLS (bumpless transfer) or 0.0 ~ 100.0 % to continue output 2 control function if the sensor fails, or select ON (0) or OFF (1) for alarm function.	0
O2HY	Output 2 hysteresis value when output 2 performs alarm function	Low: 0.1 High: 50.0 C (90.0 F)	0.1 C (0.2 F)
CYC2	Output 2 cycle time	Low: 0.1 High: 90.0 sec.	18.0
CPB	Cooling proportional band value	Low: 50 High: 300 %	100


Parameter Notation	Parameter Description	Range	Default Value
DB	Heating-cooling dead band (negative value=overlap)	Low: -36.0 High: 36.0 %	0
ALFN	Alarm function for alarm output	0 nonE :No alarm function 1 t, nr :Dwell timer action 2 dE.H :Deviation high alarm 3 dE.Lo :Deviation low alarm 4 db.H :Deviation band out of band alarm 5 db.Lo :Deviation band in band alarm 6 Pv.H :Process value high alarm 7 Pv.Lo :Process value low alarm	2
ALMD	Alarm operation mode	0 nor n : Normal alarm action 1 Ltch : Latching alarm action 2 Hold : Hold alarm action 3 Lt.Ho : Latching & Hold action	0
ALHY	Hysteresis control of alarm	Low: 0.1 High: 50.0 C (90.0 F)	0.1 C (0.2 F)
ALFT	Alarm failure transfer mode	0 on : Alarm output ON as unit fails 1 off : Alarm output OFF as unit fails	0
COMM	Communication function	0 nonE : No communication 1 r tu : Modbus RTU mode protocol 2 4-20 :4-20mA retransmission output 3 0-20 :0-20mA retransmission output 4 0-5v :0-5V retransmission output 5 1-5v :1-5V retransmission output 6 0- 10 :0-10V retransmission output	1


Parameter Notation	Parameter Description	Range	Default Value
ADDR	Address assignment of digital communication	Low: 1 High: 255	—
BAUD	Baud rate of digital communication	0 2.4 : 2.4 Kbits/s baud rate 1 4.8 : 4.8 Kbits/s baud rate 2 9.6 : 9.6 Kbits/s baud rate 3 14.4 : 14.4 Kbits/s baud rate 4 19.2 : 19.2 Kbits/s baud rate 5 28.8 : 28.8 Kbits/s baud rate 6 38.4 : 38.4 Kbits/s baud rate	2
DATA	Data bit count of digital communication	0 7b, t : 7 data bits 1 8b, t : 8 data bits	1
PARI	Parity bit of digital communication	0 Even : Even parity 1 odd : Odd parity 2 none : No parity bit	0
STOP	Stop bit count of digital communication	0 1b, t : One stop bit 1 2b, t : Two stop bits	0
RELO	Retransmission low scale value	Low: -19999 High: 45536	0.0 C (32.0 F)
REHI	Retransmission high scale value	Low: -19999 High: 45536	100.0 C (212.0 F)
SEL1	Select 1'st parameter for user menu	0 none : No parameter selected 1 LOCK : LOCK is put ahead 2 INPT : INPT is put ahead 3 UNIT : UNIT is put ahead 4 DP : DP is put ahead 5 SHIF : SHIF is put ahead 6 PB : PB is put ahead 7 TI : TI is put ahead	2


Parameter Notation	Parameter Description	Range	Default Value
SEL1	Select 1st parameter for user menu	8 <i>td</i> : TD is put ahead 9 <i>o1HY</i> : O1HY is put ahead 10 <i>[4[1</i> : CYC1 is put ahead 11 <i>oF5t</i> : OFST is put ahead 12 <i>r.r</i> : RR is put ahead 13 <i>o2HY</i> : O2HY is put ahead 14 <i>[4[2</i> : CYC2 is put ahead 15 <i>[Pb</i> : CPB is put ahead 16 <i>db</i> : DB is put ahead 17 <i>Addr</i> : ADDR is put ahead 18 <i>ALHY</i> : ALHY is put ahead	2
SEL2	Select 2nd parameter for user menu	Same as SEL1	3
SEL3	Select 3rd parameter for user menu	Same as SEL1	4
SEL4	Select 4th parameter for user menu	Same as SEL1	6
SEL5	Select 5th parameter for user menu	Same as SEL1	7
SEL6	Select 6th parameter for user menu	Same as SEL1	8
SEL7	Select 7th parameter for user menu	Same as SEL1	10
SEL8	Select 8th parameter for user menu	Same as SEL1	17

Chapter 2 Installation

 Dangerous voltages capable of causing death may be present in this instrument. Before installation or beginning any cleaning or troubleshooting procedures the power to all equipment must be switched off and isolated. Units suspected of being faulty must be disconnected and removed to a properly equipped workshop for testing and repair. Component replacement and internal adjustments must be made by a qualified maintenance person only.

 This instrument is protected throughout by **Double Insulation** . To minimize the possibility of fire or shock hazards, do not expose this instrument to rain or excessive

 Do not use this instrument in areas under hazardous conditions such as excessive shock, vibration, dirt, moisture, corrosive gases or oil. The ambient temperature of the areas should not exceed the maximum rating specified in Chapter 6.

 Remove stains from this instrument using a soft, dry cloth. Don't use harsh chemicals, volatile solvents, such as thinners or strong detergents to clean the instrument in order to avoid deformation or discoloration.

2-1 Unpacking

Upon receipt of the shipment remove the unit from the carton and inspect the unit for shipping damage.

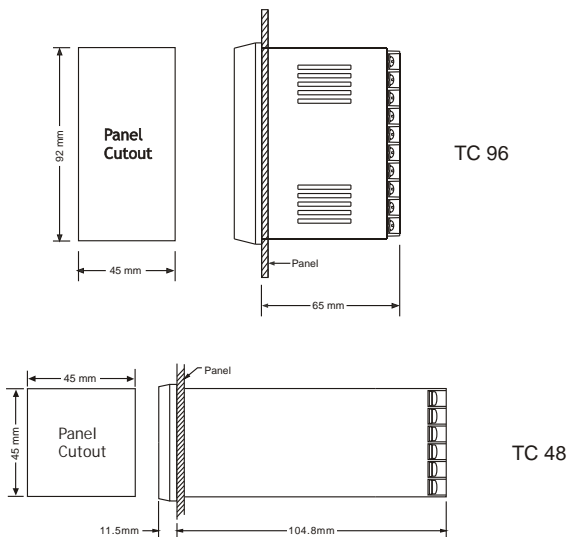
If any damage due to transit, report and claim with the carrier. Write down the model number, serial number, and date code for future reference when corresponding with our service center. The serial number (S/N) and date code (D/C) are labeled on the box and the housing of control.

2-2 Mounting

Make panel cutout to dimension shown in Figure 2.1.

Remove both mounting clamps and insert the controller into panel cutout. Reinstall the mounting clamps. Gently tighten the screws in the clamp until the controller front panel is fitted snugly in the cutout.

Figure 2.1 Mounting Dimensions



2 - 3 Wiring Precautions

- Before wiring, verify the label for correct model number and options. Switch off the power while checking.
- Care must be taken to ensure that maximum voltage rating specified on the label is not exceeded.
- It is recommended that power to these units be protected by fuses or circuit breakers rated at the minimum value possible.
- All units should be installed inside a suitably grounded metal enclosure to prevent live parts being accessible by human hands and metal tools.
- All wiring must conform to appropriate standards of good practice and local codes and regulations. Wiring must be suitable for voltage, current, and temperature rating of the system.
- Beware not to over-tighten the terminal screws. The torque should not exceed 1 N-m (8.9 Lb-In or 10.2KgF-cm).

- Unused control terminals should not be used as jumper points as they may be internally connected, causing damage to the unit.
- Verify that the ratings of the output devices and the inputs as specified in Chapter 6 are not exceeded.
- Except the thermocouple wiring, all wiring should use stranded copper conductor with maximum gauge 18AWG.

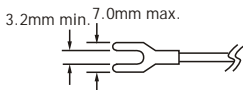


Figure 2.2 Lead Termination for TC 96

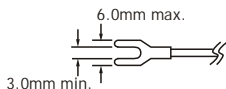


Figure 2.3 Lead Termination for TC 48

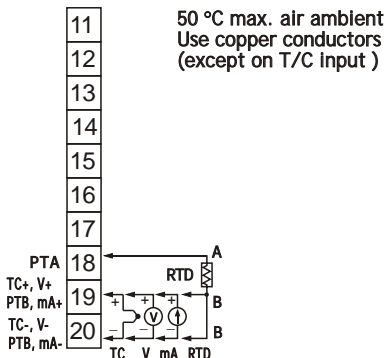
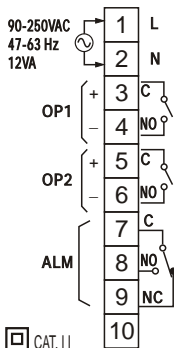
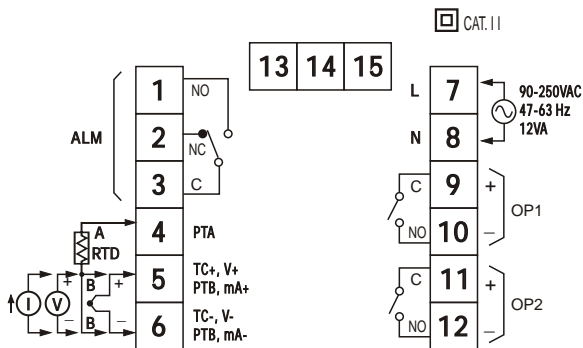


Figure 2.4 Rear Terminal Connection TC 96



50°C max. air ambient

Use copper conductors (except on T/C input)

Figure 2.5

Rear Terminal Connection for TC 48

2 - 4 Power Wiring

The controller is supplied to operate at 11-26 VAC / VDC or 90-250 VAC. Check that the installation voltage corresponds with the power rating indicated on the product label before connecting power to the controller. Near the controller a fuse and a switch rated at 2A/250VAC should be equipped as shown in the following diagram.

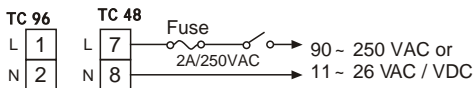


Figure 2.6 Power Supply Connections



This equipment is designed for installation in an enclosure which provides adequate protection against electric shock. The enclosure must be connected to earth ground.

Local requirements regarding electrical installation should be rigidly observed. Consideration should be given to prevent from unauthorized person access to the power terminals.

2-5 Sensor Installation Guidelines

Proper sensor installation can eliminate many problems in a control system. The probe should be placed so that it can detect any temperature change with minimal thermal lag. In a process that requires fairly constant heat output, the probe should be placed close to the heater. In a process where the heat demand is variable, the probe should be close to the work area. Some experiments with probe location are often required to find this optimum position.

In a liquid process, addition of a stirrer will help to eliminate thermal lag. Since the thermocouple is basically a point measuring device, placing more than one thermocouple in parallel can provide an average temperature readout and produce better results in most air heated processes.

Proper sensor type is also a very important factor to obtain precise measurements. The sensor must have the correct temperature range to meet the process requirements. In special processes the sensor might need to have different requirements such as leak-proof, anti-vibration, antiseptic, etc.

Standard sensor limits of error are ± 4 degrees F (± 2 degrees C) or 0.75% of sensed temperature (half that for special) plus drift caused by improper protection or an over-temperature occurrence. This error is far greater than controller error and cannot be corrected on the sensor except by proper selection and replacement.

2-6 Sensor Input Wiring

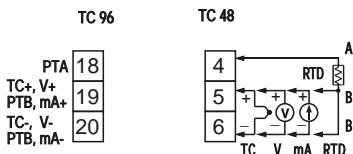


Figure 2.7 Sensor Input Wiring

2-7 Control Output Wiring

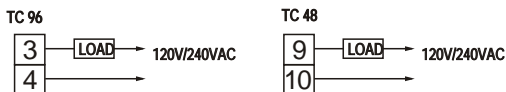


Figure 2.8 Output 1 Relay

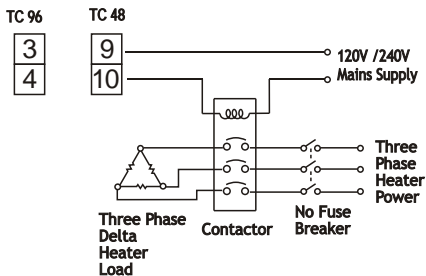


Figure 2.9
Output 1 Relay to Drive Contactor

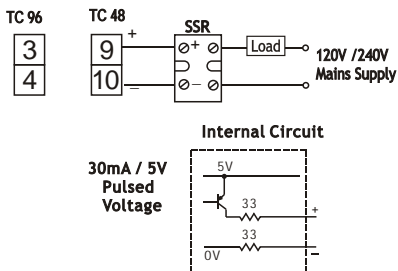


Figure 2.10 Output 1 Pulsed Voltage to Drive SSR

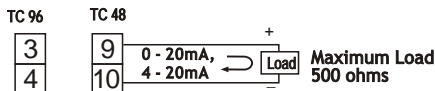


Figure 2.11 Output 1 Linear Current

2-8 Alarm Wiring

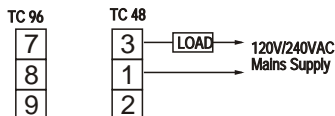


Figure 2.12 Alarm Output to Drive Load

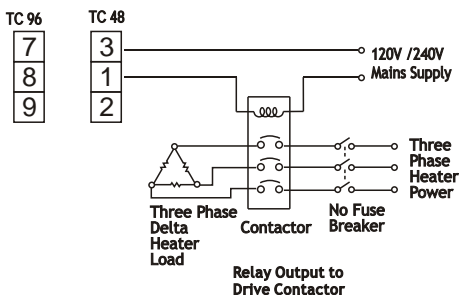




Figure 2.13 Alarm Output to Drive Contactor

Chapter 3 Programming

Press  for 5 seconds and release to enter setup menu. Press  to select the desired parameter. The upper display indicates the parameter symbol, and the lower display indicates the selected value of parameter.

3-1 Lockout

There are four security levels can be selected by using LOCK parameter.

If **NONE** is selected for LOCK, then no parameter is locked.

If **SET** is selected for LOCK, then all setup data are locked.

If **USER** is selected for LOCK, then all setup data as well as user data (refer to **section 1-5**) except set point are locked to prevent from being changed.

If **ALL** is selected for LOCK, then all parameters are locked to prevent from being changed.

3-2 Signal Input

INPT: Selects the sensor type or signal type for signal input.

Range: (thermocouple) J_TC, K_TC, T_TC, E_TC, B_TC, R_TC
S_TC, N_TC, L_TC
(RTD) PT.DN, PT.JS
(linear) 4-20, 0-20, 0-60, 0-1V, 0-5V, 1-5V, 0-10

UNIT: Selects the process unit

Range: °C, °F, PU(process unit). If the unit is neither °C nor °F, then selects PU.

DP: Selects the resolution of process value.

Range: (for T/C and RTD) NO DP, 1-DP
(for linear) NO DP, 1-DP, 2-DP, 3-DP

INLO: Selects the low scale value for the linear type input.

INHI : Selects the high scale value for the linear type input.

How to use INLO and INHI :

If 4 - 20 mA is selected for INPT, SL specifies the input signal low (ie. 4 mA), SH specifies the input signal high (ie. 20 mA), S specifies the current input signal value, the conversion curve of the process value is shown as follows :

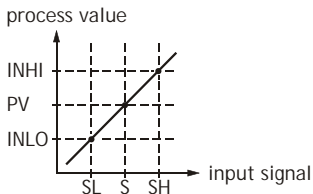


Figure 3.1
Conversion Curve for
Linear Type Process Value

Formula : $PV = INLO + (INHI - INLO) \frac{S - SL}{SH - SL}$

Example : A 4-20 mA current loop pressure transducer with range 0 - 15 kg/cm² is connected to input, then perform the following setup :

INPT = 4 - 20 INLO = 0.00

INHI = 15.00 DP = 2-DP

Of course, you may select other value for DP to alter the resolution.

3-3 Control Outputs

There are 4 kinds of control modes can be configured as shown in **Table 3.1**

Table 3.1 Heat-Cool Control Setup Value

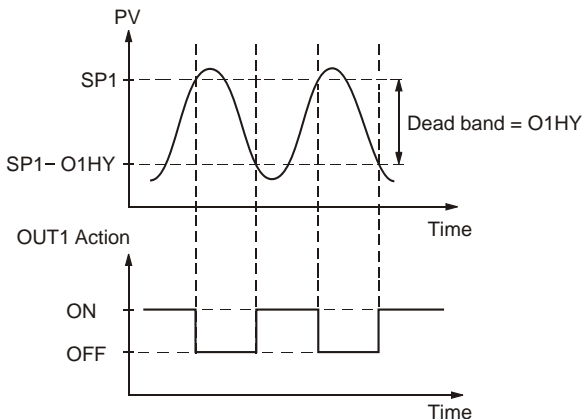
Control Modes	OUT1	OUT2	O1HY	O2HY	CPB	DB
Heat only	REVR	×	☆	×	×	×
Cool only	DIRT	×	☆	×	×	×
Heat: PID Cool: ON-OFF	REVR	DE.HI	×	○	×	×
Heat: PID Cool: PID	REVR	COOL	×	×	○	○

× : Don't care

○ : Adjust to met process requirements

☆: Required if ON-OFF control is configured

Heat Only ON-OFF Control : Select REVR for OUT1, Set PB to 0, O1HY is used to adjust dead band for ON-OFF control, The output 1 hysteresis (O1HY) is enabled in case of PB = 0 . The heat only on-off control function is shown in the following diagram :



**Figure 3.2 Heat Only
ON-OFF Control**

The ON-OFF control may introduce excessive process oscillation even if hysteresis is minimized to the smallest. If ON-OFF control is set (ie. PB = 0), TI, TD, CYC1, OFST, CYC2, CPB, DB will be hidden and have no function to the system. The auto-tuning mode and bumpless transfer will be disabled too.

Heat only P (or PD) control : Select REVR for OUT1, set TI to 0, OFST is used to adjust the control offset (manual reset). O1HY is hidden if PB is not equal to 0. **OFST Function :** OFST is measured by % with range 0 - 100.0 %. In the steady state (ie. process has been stabilized) if the process value is lower than the set point a definite value, say 5 °C, while 20 °C is used for PB, that is lower 25%.

then increase OFST 25 %, and vice versa. After adjusting OFST value, the process value will be varied and eventually, coincide with set point. Using the P control (TI set to 0), the auto-tuning is disabled. Refer to section 3-12 " manual tuning " for the adjustment of PB and TD. Manual reset (adjust OFST) is not practical because the load may change from time to time and therefore, the need to adjust OFST repeatedly. The PID control can avoid this situation.

Heat only PID control : Selecting REVR for OUT1, PB and TI should not be zero. Operate auto-tuning for the new process, or set PB, TI and TD with historical values. See section 3-11 for auto-tuning operation. If the control result is still unsatisfactory, then use manual tuning to improve the control . See section 3-12 for manual tuning. The unit contains a **very clever PID and Fuzzy** algorithm to achieve a **very small overshoot and very quick response** to the process if it is properly tuned.

Cool only control: ON-OFF control, P (PD) control and PID control can be used for cool control. Set OUT1 to DIRT (direct action). The other functions for cool only ON-OFF control, cool only P (PD) control and cool only PID control are same as descriptions for heat only control except that the output variable (and action) for the cool control is inverse to the heat control.

NOTE : The ON-OFF control may result excessive overshoot and undershoot problems in the process. The P (or PD) control will result in a deviation process value from the set point. It is recommended to use PID control for the Heat-Cool control to produce a stable and zero offset process value.

Other Setup Required : O1TY, CYC1, O2TY, CYC2, O1FT, O2FT
O1TY & O2TY are set in accordance with the types of OUT1 & OUT2 installed. CYC1 & CYC2 are selected according to the output 1 type (O1TY) & output 2 type (O2TY). Generally, select 0.5 ~ 2 sec. for CYC1, if SSRD or SSR is used for O1TY; 10 ~ 20 sec. if relay is used for O1TY, and CYC1 is ignored if linear output is used. Similar condition is applied for CYC2 selection.

You can use the **auto-tuning** program for the new process or directly set the appropriate values for PB, TI & TD according to experience. If the control behavior is still inadequate, then use **manual tuning** to improve the control. See **section 3-12** for manual tuning.

CPB Programming : The cooling proportional band is measured by % of PB with range 50~300. Initially set 100% for CPB and examine the cooling effect. If cooling action is too slow then decrease CPB, if cooling action is too fast then increase CPB. The value of CPB is related to PB and its value remains unchanged throughout the auto-tuning procedures.

Adjustment of CPB is related to the cooling media used. For air used as cooling media, adjust CPB at 100(%). For oil used as cooling media, adjust CPB at 125(%). For water used as cooling media, adjust CPB at 250(%).

DB Programming: Adjustment of DB is dependent on the system requirements. If more positive value of DB (greater dead band) is used, an unwanted cooling action can be avoided but an excessive overshoot over the set point will occur. If more negative value of DB (greater overlap) is used, an excessive overshoot over the set point can be minimized but an unwanted cooling action will occur. It is adjustable in the range -36.0% to 36.0 % of PB. A negative DB value shows an overlap area over which both outputs are active. A positive DB value shows a dead band area over which neither

Output 2 ON-OFF Control (Alarm function): Output 2 can also be configured as alarm function. There are 4 alarm functions that can be selected for output 2: **DE.HI** (deviation high alarm), **DE.LO** (deviation low alarm), **PV.HI** (process high alarm) and **PV.LO** (process low alarm). Refer to **Figure 3.3** and **Figure 3.4** for the description of deviation alarm and process alarm.

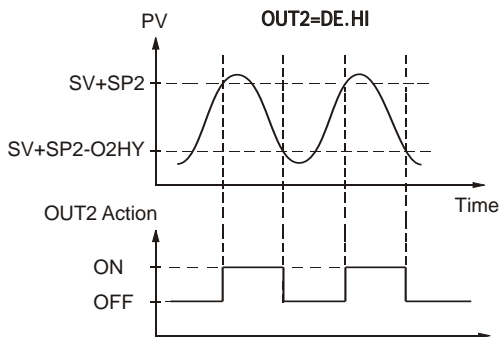


Figure 3.3 Output 2 Deviation High Alarm

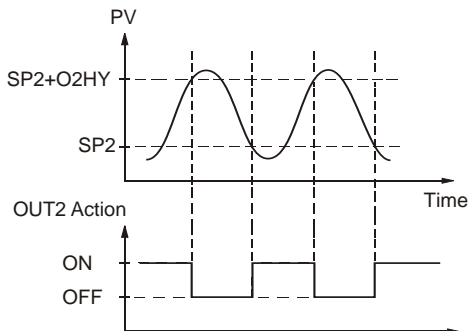


Figure 3.4 Output 2 Process Low Alarm

3-4 Alarm

The controller has one alarm output. There are 6 alarm functions and one dwell timer that can be selected, and four kinds of alarm modes (ALMD) are available for each alarm function (ALFN). Besides the alarm output, the output 2 can also be configured as another alarm. But output 2 only provides 4 kinds of alarm functions and only normal alarm mode is available for this alarm.

A process alarm sets two absolute trigger levels. When the process goes higher than SP3, a process high alarm (PV.HI) occurs, and the alarm turns off as the process goes lower than SP3-ALHY. When the process goes lower than SP3, a process low alarm (PV.LO) occurs and the alarm turns off as the process is higher than SP3+ALHY. A process alarm is independent of set point.

A deviation alarm alerts the user when the process deviates too far from set point. When the process goes higher than SV+SP3, a deviation high alarm (DE.HI) occurs and the alarm turns off as the process goes lower than SV+SP3-ALHY. When the process goes lower than SV+SP3, a deviation low alarm (DE.LO) occurs and the alarm turns off as the process goes higher than SV+SP3+ALHY. Trigger level of deviation alarm is moving with set point.

A deviation band alarm presets two trigger levels relative to set point. The two trigger levels are SV+SP3 and SV - SP3 for alarm. When the process is higher than (SV+SP3) or lower than (SV - SP3), a deviation band high alarm (DB.HI) occurs. When the process is within the trigger levels, a deviation band low alarm (DB.LO) occurs.

In the above descriptions SV denotes the current set point value for control which is different from SP1 as the ramp function is performed.

There are four types of alarm modes available for each alarm function, these are: Normal alarm, Latching alarm, Holding alarm and Latching/Holding alarm. They are described as follows:

Normal Alarm : ALMD = NORM

When a normal alarm is selected, the alarm output is de-energized in the non-alarm condition and energized in an alarm condition.

Latching Alarm : ALMD = LTCH

If a latching alarm is selected, once the alarm output is energized, it will remain unchanged even if the alarm condition is cleared. The latching alarm is reset when the RESET key is pressed, once the alarm condition is removed.

Holding Alarm : ALMD = HOLD

A holding alarm prevents an alarm at power up. The alarm is enabled only when the process reaches the set point value. Afterwards, the alarm performs same function as normal alarm.

Latching / Holding Alarm : ALMD = LT.HO

A latching / holding alarm performs both holding and latching function. The latching alarm is reset when the RESET key is pressed, once the alarm condition is removed.

Alarm Failure Transfer is activated as the unit enters **failure mode**.

Alarm will go on if **ON** is set for **ALFT** and go off if **OFF** is set for **ALFT**. The unit will enter failure mode when sensor break occurs or if the A-D converter of the unit fails.

3-5 Configure User Menu

Conventional controllers are designed with a fixed parameters' scrolling. This unit has the flexibility for you to select those parameters which are most significant to you and put these parameters in the front of display sequence.

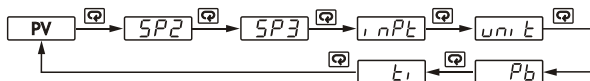
SEL1~SEL8 : Selects the parameter for view and change in the user menu.

Range : LOCK, INPT, UNIT, DP, SHIF, PB, TI, TD, O1HY, CYC1, OFST, RR, O2HY, CYC2, CPB, DB, ADDR, ALHY

When using the up-down key to select the parameters, you may not obtain all of the above parameters. The number of visible parameters is dependent on the setup condition. The hidden parameters for the specific application are also deleted from the SEL selection.

Example :

OUT2 selects DE.LO PB= 100.0 SEL1 selects INPT
 SEL2 selects UNIT SEL3 selects PB SEL4 selects TI
 SEL5-SEL8 selects NONE Now, the upper display scrolling becomes :



3 - 6 Ramp

The ramping function is performed during power up as well as any time the set point is changed. Choose MINR or HRR for RAMP, as the time unit for the ramping function. The ramp rate is programmed by adjusting RR. The ramping function is disabled as soon as the failure mode, the manual control mode, the auto-tuning mode or the calibration mode occurs.

Example without Dwell Timer

Select MINR for RAMP, select °C for UNIT, selects 1-DP for DP, Set RR= 10.0. SV is set to 200 °C initially, and changed to 100 °C 30 minutes after power up. The starting temperature is 30 °C. After power up the process is running like the curve shown below:

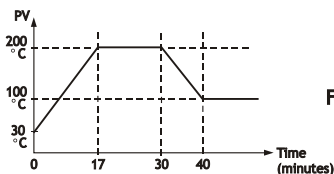


Figure 3.5 RAMP Function

Note: When the ramp function is used, the lower display will show the current ramping value. However it will revert to show the set point value as soon as the up or down key is touched for adjustment. Ramping is applied at power up, or when RR and /or set point are changed. Setting RR to zero means no ramp function at all.

3-7 Dwell Timer

Alarm output can be configured as dwell timer by selecting TIMR for ALFN . As the dwell timer is configured, the parameter SP3 is used for dwell time adjustment. The dwell time is measured in minutes, into the range of 0.1 to 4553.6. Once the process reaches the set point the dwell timer starts to time down to zero (time out). The alarm relay will remain off until time out. The dwell timer operation is shown as following diagram.

After time out the dwell timer will be restarted by pressing the RESET key.

The timer stops during the manual control mode, failure mode, calibration period and auto-tuning period.

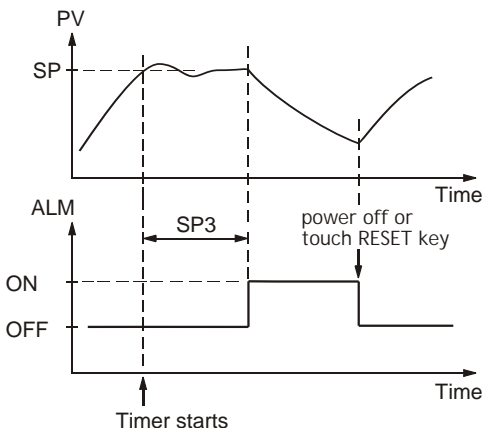


Figure 3.6 Dwell Timer Function

If alarm is configured as dwell timer, ALHY and ALMD are hidden.

3 - 8 PV Shift

In certain applications it is desirable to shift the controller display value from its actual value. This can be easily accomplished by using the PV shift function.

The SHIF function will alter PV only.

Here is an example. A process is equipped with a heater, a sensor and a subject to be warmed up. Due to the design and position of the components in the system, the sensor could not be placed any closer to the part. Thermal gradient (different temperature) is common and necessary to an extent in any thermal system for heat to be transferred from one point to another. If the difference between the sensor and the subject is 35 °C, and the desired temperature at the subject to be heated is 200 °C, the controlling value or the temperature at the sensor should be 235 °C. You should input -35 °C as to subtract 35 °C from the actual process display. This in turn will cause the controller to energize the load and bring the process display up to the set point value.

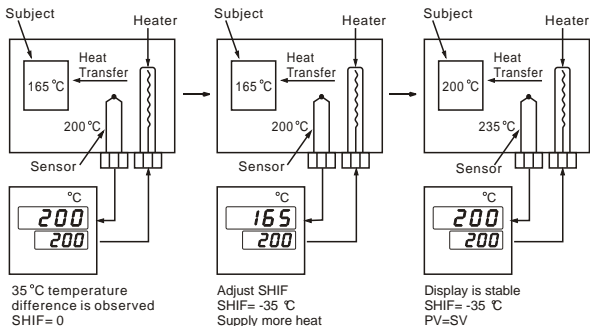


Figure 3.7
PV Shift Application

3- 9 Digital Filter

In certain application the process value is too unstable to be read. To improve this a programmable low pass filter incorporated in the controller can be used. This is a first order filter with time constant specified by **FILT** parameter . The default value of **FILT** is 0.5 sec. before shipping. Adjust **FILT** to change the time constant from 0 to 60 seconds. 0 second represents no filter is applied to the input signal. The filter is characterized by the following diagram.

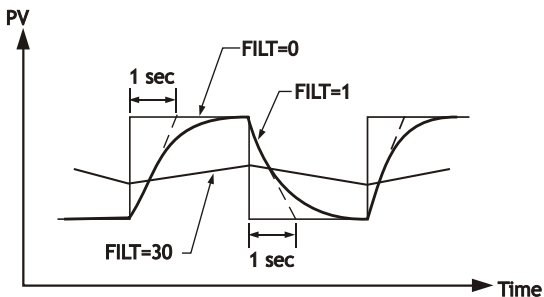


Figure 3.8
Filter Characteristics

Note

The Filter affects the PV display only, in order to make it readable. The control uses the unfiltered PV for actual control purposes.

3 -10 Failure Transfer

The controller will enter **failure mode** as one of the following conditions occurs:

1. **SBER** occurs due to the input sensor break or input current below 1mA if 4-20 mA is selected or input voltage below 0.25V if 1-5 V is selected .
2. **ADER** occurs due to the A-D converter failure.

Output 1 and output 2 will perform the **failure transfer** function as the controller enters failure mode.

Output 1 Failure Transfer, if activated, will perform :

1. If output 1 is configured as proportional control (PB≠0), and BPLS is selected for O1FT, then output 1 will perform bumpless transfer. Thereafter the previous averaging value of MV1 will be used for controlling output 1.
2. If output 1 is configured as proportional control (PB≠0), and a value of 0 to 100.0 % is set for O1FT, then output 1 will perform failure transfer. Thereafter the value of O1FT will be used for controlling output 1.
3. If output 1 is configured as ON-OFF control (PB=0), then output 1 will transfer to off state if OFF is set for O1FT and transfer to on state if ON is set for O1FT.

Output 2 Failure Transfer, if activated, will perform :

1. If OUT2 is configured as COOL, and BPLS is selected for O2FT, then output 2 will perform bumpless transfer. Thereafter the previous averaging value of MV2 will be used for controlling output 2.
2. If OUT2 is configured as COOL, and a value of 0 to 100.0 % is set for O2FT, then output 2 will perform failure transfer. Thereafter the value of O2FT will be used for controlling output 2.
3. If OUT2 is configured as alarm function, and OFF is set for O2FT, then output 2 will transfer to off state, otherwise, output 2 will transfer to on state if ON is set for O2FT.

Alarm Failure Transfer is activated as the controller enters failure mode. Thereafter the alarm will transfer to the ON or OFF state which is determined by the set value of ALFT.

3 -11 Auto-tuning






The auto-tuning process is performed at set point.
The process will oscillate around the set point during tuning process. Set a set point to a lower value if overshooting beyond the normal process value is likely to cause damage.

The auto-tuning is applied in cases of :

- * Initial setup for a new process
- * The set point is changed substantially from the previous auto- tuning value
- * The control result is unsatisfactory

Operation :

1. The system has been installed normally.
2. Set the correct values for the setup menu of the unit.
But don't use a zero value for PB and TI , otherwise, the auto-tuning program will be disabled. The LOCK parameter should be set at NONE.
3. Set the set point to a normal operating value or a lower value if overshooting beyond the normal process value is likely to cause damage.
4. Press  and hold until  appears on the display.
5. Press  for at least 5 seconds. The AT indicator will begin to flash and the auto-tuning procedure is beginning.

NOTE :

The ramping function, if used, will be disabled once auto-tuning is proceeding.

The auto-tuning mode is disabled as soon as either failure mode or manual control mode occurs.

Procedures:

The auto-tuning can be applied either as the process is warming up (Cold Start) or as the process has been in steady state (Warm Start).

After the auto-tuning procedures are completed, the AT indicator will cease to flash and the unit revert to PID control by using its new PID values. The PID values obtained are stored in the nonvolatile memory.

ATER Auto-Tuning Error

If auto-tuning fails an ATER message will appear on the upper display in cases of :

- If PB exceeds 9000 (9000 PU, 900.0 °F or 500.0 °C).
- or if TI exceeds 1000 seconds.
- or if set point is changed during auto-tuning procedure.

Solutions to **ATER**

1. Try auto-tuning once again.
2. Don't change set point value during auto-tuning procedure.
3. Don't set zero value for PB and TI.
4. Use manual tuning instead of auto-tuning. (See section 3-12).
5. Touch RESET key to reset **ATER** message.

3 - 12 Manual Tuning

In certain applications (very few) using auto-tuning to tune a process may be inadequate for the control requirement, then you can try manual tuning.

Use the following guide to adjust P, I, & D during manual tuning:








ADJUSTMENT SEQUENCE	SYMPTOM	SOLUTION
(1) Proportional Band (PB)	Slow Response	Decrease PB
	High overshoot or Oscillations	Increase PB
(2) Integral Time (TI)	Slow Response	Decrease TI
	Instability or Oscillations	Increase TI
(3) Derivative Time (TD)	Slow Response or Oscillations	Decrease TD
	High Overshoot	Increase TD

Table 3.2 PID Adjustment Guide

Figure 3.9 shows the effects of PID adjustment on process response.

3 -13 Manual Control

Operation:

To enable manual control the LOCK parameter should be set with NONE, then press  for 6.2 seconds   (Hand Control) will appear on the display. Press  for 5 seconds then the MAN indicator will begin to flash and the lower display will show  . The controller now enters the manual control mode.  indicates output control variable for output 1, and  indicates control variable for output 2. Now you can use up-down key to adjust the percentage values for the heating or cooling output.

The controller performs open loop control as long as it stays in manual control mode.

Exit Manual Control

Press  to return to closed loop control mode.

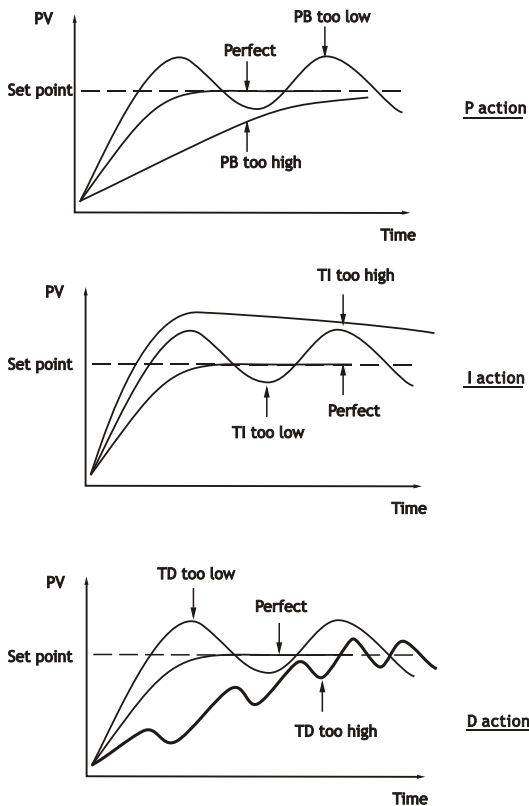
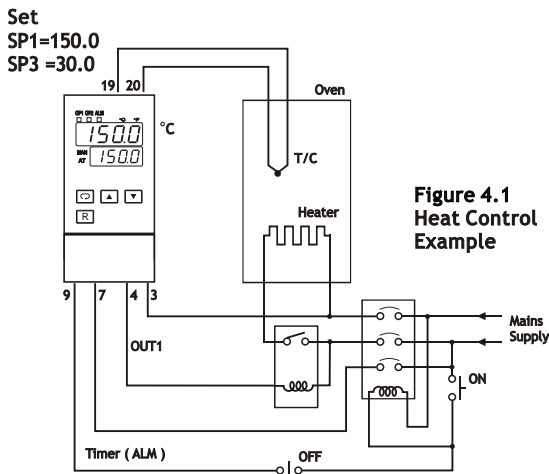


Figure 3.9 Effects of PID Adjustment

Chapter 4 Applications

4 - 1 Heat Only Control with Dwell Timer

An oven is designed to dry the products at 150 °C for 30 minutes and then stay unpowered for another batch. A TC 96 equipped with **dwell timer** is used for this purpose. The system diagram is shown as follows :



To achieve this function set the following parameters in the setup menu.

INPT=K_TC

UNIT= °C

DP=1_DP

OUT1=REVR

O1TY=RELY

CYC1=18.0

O1FT=BPLS

ALFN=TIMR

ALFT=ON

Auto-Tuning is performed at 150 °C for a new oven.

4 - 2 Cool Only Control

A TC 96 is used to control a refrigerator at temperature below 0 °C. The temperature is lower than the ambient, a cooling action is required. Hence select DIRT for OUT1. Since output 1 is used to drive a magnetic contactor, O1TY selects RELY. A small temperature oscillation is tolerable, hence use ON-OFF control to reduce the over-all cost. To achieve ON-OFF control, PB is set with zero and O1HY is set at 0.1 °C.

Setup Summary:

INPT=PT.DN

UNIT= °C

DP=1-DP

OUT1=DIRT

O1TY=RELY

User Menu:

PB = 0 (°C)

O1HY=0.1 (°C)

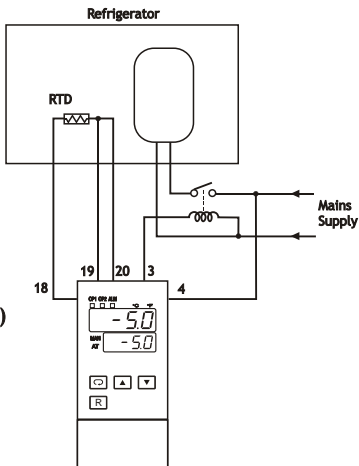



Figure 4.2
Cooling Control Example

Chapter 5 Calibration

 CALIBRATION SHOULD BE DONE ONLY BY EXPERIENCED PERSONNEL WITH APPROPRIATE CALIBRATION EQUIPMENT. THE USE OF A CERTIFIED CALIBRATION LABORATORY IS HIGHLY RECOMMENDED.

FOR DETAILED CALIBRATION INSTRUCTIONS, OR FOR ADDITIONAL INFORMATION, PLEASE CONTACT YOUR LOCAL EATON REPRESENTATIVE OR CALL EATON CARE AT 877-ETN-CARE.

Chapter 6 Specifications

Power

90 – 250 VAC, 47– 63 Hz, 12VA, 5W maximum

11– 26 VAC / VDC, 12VA, 5W maximum

Input

Resolution : 18 bits

Sampling Rate : 5 times / second

Maximum Rating : -2 VDC minimum, 12 VDC maximum

(1 minute for mA input)

Temperature Effect : $\pm 1.5\mu\text{V}/^{\circ}\text{C}$ for all inputs except
mA input

$\pm 3.0\mu\text{V}/^{\circ}\text{C}$ for mA input

Sensor Lead Resistance Effect :

T/C: $0.2\mu\text{V}/\text{ohm}$

3-wire RTD: $2.6^{\circ}\text{C}/\text{ohm}$ of resistance difference of two
leads

2-wire RTD: $2.6^{\circ}\text{C}/\text{ohm}$ of resistance sum of two leads

Burn-out Current : 200 nA

Common Mode Rejection Ratio (CMRR): 120dB

Normal Mode Rejection Ratio (NMRR): 55dB

Sensor Break Detection :

Sensor open for TC, RTD and mV inputs,

Sensor short for RTD input

below 1 mA for 4-20 mA input,

below 0.25V for 1 - 5 V input,

unavailable for other inputs.

Sensor Break Responding Time :

Within 4 seconds for TC, RTD and mV inputs,

0.1 second for 4-20 mA and 1 - 5 V inputs.

Characteristics:

Type	Range	Accuracy @ 25 °C	Input Impedance
J	-120°C – 1000°C (-184°F – 1832°F)	+/-2 °C	2.2 MΩ
K	-200°C – 1370°C (-328°F – 2498°F)	+/-2 °C	2.2 MΩ
T	-250°C – 400 °C (-418°F – 752 °F)	+/-2 °C	2.2 MΩ
E	-100°C – 900 °C (-148°F – 1652°F)	+/-2 °C	2.2 MΩ
B	0°C – 1800°C (32 °F – 3272 °F)	+/-2 °C (200°C – 1800°C)	2.2 MΩ
R	0 °C – 1767.8 °C (32 °F – 3214 °F)	+/-2 °C	2.2 MΩ
S	0°C – 1767.8 °C (32 °F – 3214 °F)	+/-2 °C	2.2 MΩ
N	-250°C – 1300 °C (-418°F – 2372 °F)	+/-2 °C	2.2 MΩ
L	-200°C – 900 °C (-328°F – 1652 °F)	+/-2 °C	2.2 MΩ
PT100 (DIN)	-210°C – 700 °C (-346°F – 1292 °F)	+/-0.4 °C	1.3 KΩ
PT100 (JIS)	-200°C – 600 °C (-328°F – 1112 °F)	+/-0.4 °C	1.3 KΩ
mV	-8mV – 70mV	+/-0.05 %	2.2 MΩ
mA	-3mA – 27mA	+/-0.05 %	70.5Ω
V	-1.3V – 11.5V	+/-0.05 %	650 KΩ

Output 1 / Output 2

Relay Rating : 2A/240 VAC, life cycles 200,000 for resistive load

Pulsed Voltage : Source Voltage 5V,
current limiting resistance 66 Ω .

Linear Output Characteristics

Type	Zero Tolerance	Span Tolerance	Load Capacity
4~20 mA	3.6~4 mA	20~21 mA	500 Ω max.
0~20 mA	0 mA	20~21 mA	500 Ω max.
0 ~ 5 V	0 V	5 ~ 5.25 V	10 K Ω min.
1 ~ 5 V	0.9 ~ 1 V	5 ~ 5.25 V	10 K Ω min.
0 ~ 10 V	0 V	10 ~10.5 V	10 K Ω min.

Linear Output

Resolution :15 bits

Output Regulation : 0.02 % for full load change

Output Settling Time : 0.1 sec. (stable to 99.9 %)

Isolation Breakdown Voltage : 1000 VAC

Temperature Effect : +/-0.01 % of SPAN / $^{\circ}\text{C}$

Triac (SSR) Output

Rating : 1A / 240 VAC

Inrush Current : 20A for 1 cycle

Min. Load Current : 50 mA rms

Max. Off-state Leakage : 3 mA rms

Max. On-state Voltage : 1.5 V rms

Insulation Resistance : 1000 Mohms min. at 500 VDC

Dielectric Strength : 2500 VAC for 1 minute

DC Voltage Supply Characteristics (Installed at Output 2)

Type	Tolerance	Max. Output Current	Ripple Voltage	Isolation Barrier
20 V	A1 V	25 mA	0.2 Vp-p	500 VAC
12 V	A0.6 V	40 mA	0.1 Vp-p	500 VAC
5 V	A0.25 V	80 mA	0.05 Vp-p	500 VAC

Alarm

Alarm Relay : Form C Rating

2A/240VAC, life cycles 200,000 for resistive load.

Alarm Functions : Dwell timer, Deviation High / Low Alarm,
Deviation Band High / Low Alarm,
PV High / Low Alarm,

Alarm Mode : Normal, Latching, Hold, Latching / Hold.

Dwell Timer : 0.1 - 4553.6 minutes

User Interface

Dual 4-digit LED Displays

Keypad : 4 keys

Programming Port : For automatic setup, calibration and testing

Communication Port : Connection to PC for supervisory control

Control Mode

Output 1 : Reverse (heating) or direct (cooling) action
Output 2 : PID cooling control, cooling P band 50~300%
 of PB, dead band -36.0 ~ 36.0 % of PB
ON-OFF : 0.1 - 90.0 (°F) hysteresis control (P band = 0)
P or PD : 0 - 100.0 % offset adjustment
PID : Fuzzy logic modified
 Proportional band 0.1 ~ 900.0 °F.
 Integral time 0 - 1000 seconds
 Derivative time 0 - 360.0 seconds
Cycle Time : 0.1 - 90.0 seconds
Manual Control : Heat (MV1) and Cool (MV2)
Auto-tuning : Cold start and warm start
Failure Mode : Auto-transfer to manual mode while
 sensor break or A-D converter damage
Ramping Control : 0 - 900.0 °F/minute or
 0 - 900.0 °F/hour ramp rate

Digital Filter

Function : First order
Time Constant : 0, 0.2, 0.5, 1, 2, 5, 10, 20, 30, 60
 seconds programmable

Environmental & Physical

Operating Temperature : -10 °C to 50 °C

Storage Temperature : -40 °C to 60 °C

Humidity : 0 to 90 % RH (non-condensing)

Altitude: 2000m maximum

Pollution: Degree 2

Insulation Resistance : 20 Mohms min. (at 500 VDC)

Dielectric Strength : 2000 VAC, 50/60 Hz for 1 minute

Vibration Resistance : 10 - 55 Hz, 10 m/s² for 2 hours

Shock Resistance : 200 m/s² (20 g)

Moldings : Flame retardant polycarbonate

Dimensions :

TC 96-----48mm(W) X 96mm(H) X 80mm(D),
65 mm depth behind panel

TC 48-----48mm(W) X 48mm(H) X 116mm(D),
105 mm depth behind panel

Weight : TC 96----- 210 grams

TC 48----- 150 grams

Approval Standards

Safety : UL61010C-1

CSA C22.2 No.24-93

EN61010-1 (IEC1010-1)

Protective Class :

IP65 for panel with additional option

IP50 for panel without additional option

IP20 for terminals and housing with protective cover.

All indoor use.

EMC: EN61326

Table A.1 Error Codes and Corrective Actions

Error Code	Display Symbol	Error Description	Corrective Action
4	<i>Er 04</i>	Illegal setup values been used: Before COOL is used for OUT2, DIRT (cooling action) has already been used for OUT1, or PID mode is not used for OUT1 (that is PB = 0, and / or TI = 0)	Check and correct setup values of OUT2, PB, TI and OUT1. IF OUT2 is required for cooling control, the control should use PID mode (PB = 0, TI = 0) and OUT1 should use reverse mode (heating action) , otherwise, don't use OUT2 for cooling control.
10	<i>Er 10</i>	Communication error: bad function code	Correct the communication software to meet the protocol requirements.
11	<i>Er 11</i>	Communication error: register address out of range	Don't issue an over-range register address to the slave.
14	<i>Er 14</i>	Communication error: attempt to write a read-only data or a protected data	Don't write a read-only data or a protected data to the slave.
15	<i>Er 15</i>	Communication error: write a value which is out of range to a register	Don't write an over-range data to the slave register.
26	<i>AtEr</i>	Fail to perform auto-tuning function	<ol style="list-style-type: none"> 1. The PID values obtained after auto-tuning procedure are out of range. Retry auto-tuning. 2. Don't change set point value during auto-tuning procedure. 3. Use manual tuning instead of auto-tuning. 4. Don't set a zero value for PB. 5. Don't set a zero value for TI. 6. Touch RESET key
29	<i>EEPE</i>	EEPROM write error	Return to factory for repair.
30	<i>CEr</i>	Cold junction compensation for thermocouple malfunction	Return to factory for repair.
39	<i>SbEr</i>	Input sensor break, or input current below 1 mA if 4-20 mA is selected, or input voltage below 0.25V if 1 - 5V is selected	Replace input sensor.
40	<i>AdEr</i>	A to D converter or related component(s) malfunction	Return to factory for repair.

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